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# Role of Ocean Memory in Subpolar North Atlantic Decadal Variability

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The decadal variability in the subpolar North Atlantic Ocean heat content is significantly influenced by the atmosphere. The impact of seasonal-annual atmospheric perturbations lasts for many years in the oceans due to the ocean's long memory. The anomalous air-sea heat fluxes and winds associated with atmospheric perturbations first rapidly modify upper ocean temperatures, initiating a short-term or local ocean response. Subsequently, these modifications can alter meridional heat transport rates, leading to anomalous heat convergence persisting for several years—a long-term or far-field ocean response—in the subpolar ocean (Khatri et al., 2022, Geophys Res Lett).

We propose a novel technique that incorporates these two ocean responses to evaluate ocean memory and examine its role in driving decadal ocean variability. Here, we combine heat budget analysis with linear response theory to examine how the North Atlantic Oscillation (NAO), which captures about 40% of atmospheric variability, controls the decadal variability in upper ocean temperatures and quantify the associated ocean memory. Utilising CMIP6 climate model outputs and observations, our estimations suggest ocean memory for the subpolar North Atlantic to be between 10 to 20 years. Furthermore, we find that the NAO strongly influences long-term ocean variability, explaining 30% to 40% of subpolar ocean heat content variability on decadal timescales. Specifically, the impact of seasonal atmospheric events on the ocean persists for more than a decade through a combination of local and far-field ocean responses. The proposed ocean memory-based framework, integrating local and far-field ocean effects into a single metric, can be utilised to analyse how relatively short-timescale atmospheric variability drives changes in the ocean state over decadal timescales.